Target development for Warm Dense Matter research

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Introduction

Carbon is one of the most abundant elements on earth. It's behavior in the Warm Dense Matter regime at very high pressures in the Mbar area and several thousand degrees Celsius is part of current research. A better understanding of carbon under these conditions is important for the understanding of planetary cores, beam dumps for accelerators or as a component of plastic in inertial confinement fusion targets and for Equation of State systems to improve and benchmark this equation [1]. These exotic states can be achieved in the laboratory by a shock wave which is driven by a laser. The final state depends on the laser intensity and the initial carbon structure and density. In previous experiments it was possible to generate liquid carbon and to prove it with X-ray scattering. This was made possible by the method of X-ray Thomson scattering, which is planned as a key diagnostic for the plasma physics research program at FAIR [2]. In the next step, the solid-liquid phase transition region should be determined more accurately. This will be intend with a new target geometry and a VISAR (Velocity Interferometer System for Any Reflector) detector.

Target design and Simulations

A novel idea is to reduce the laser intensity for the shock generation so far that there is no phase transition to the liquid state and then initiate the solid liquid phase transition using a further shock. This should be achieved by the reflection of a part of the initial shock wave from a fixed wall by a conical geometry (see figure 1).

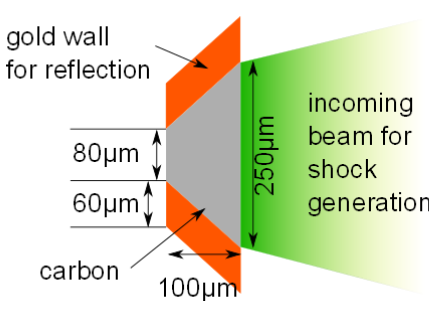

Figure 1: sketch of the cone target

The shock wave is reflected on both sides and converges at the center. Figure 2 shows a RALEF2D simulation of the target geometry [3]. In simulations it is clearly seen how the shock-wave is reflected from the gold wall resulting in an increase of the density and temperature of the shocked carbon.

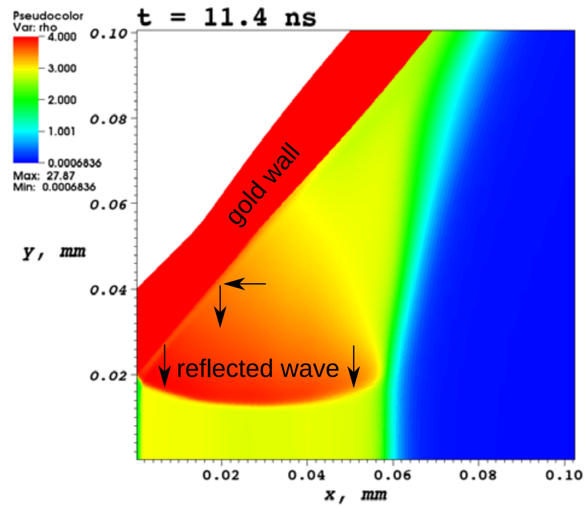

Figure 2: density increased by the reflected shock wave simulated with the RALEF2D code

The best reflective material has a high sound velocity and a high density such as osmium or uranium, but the processing, handling and safety aspects of these materials are not acceptable. The best compromise for the reflective wall is gold.

Target production

Target production is challenging due to the sub millimeter size of the samples. Cones were made from a carbon rod which was processed with a CNC precision lathe at the target laboratory of the TU Darmstadt. In the next step, the carbon was coated with gold. The gold coating was done by DC sputtering under argon in the target laboratory of GSI. For the shock wave reflection a good connection between the gold and carbon is require which is ensured by this method. This work was supported by BMBF project 05P12RDFA1.

References

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